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Electric and thermoelectric properties of ilmenite

BY A. K. MUKERJEE
Magnetism Department
Indian Association for the Cultivation of Science, Calcutta-32, India.

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In an earlier observation from 300°K to about 800°K (Mukerjee 1964), the natural crystals of ilmenite (chemical composition : TiO_2 40.1%, FeO 57.4%, SiO_2 1.2% and H_2O 0.2% ; X-ray composition analysis : ilmenite—major, hemtite—minor, rutile—trace was found to be semiconducting. The recent study of its magnetic properties (Mukerjee, to be published) shows it to be weakly ferromagnetic and that its curie temperature is about 855°K. Its principal conductivities were therefore remeasured from 300°K to 1000°K to study the electrical behaviours both below and above the Curie temperature (figure 1).

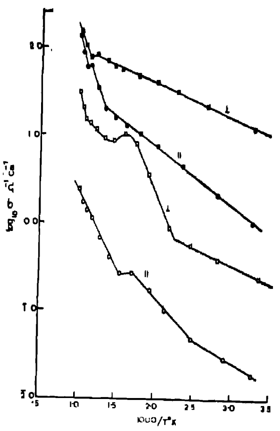

Figure 1. The conductivity of ilmenite Open and solid points indicate measurements on fresh and heated samples.

The temperature variation of principal conductivities could be given by a formula of the type

$$\sigma = \sigma_0 \exp \frac{-\triangle E}{kT}$$

where the symbols have their usual meaning (Smith 1959) but with different sets of values for σ_0 and $\triangle E$ for different temperature ranges which are given in table 1, for different crystallographic directions i.e. $\parallel$ and $\perp$ to the trigonal axis, respectively. Seebeck voltage (with respect to Pt) at different temperatures was studied in order to determine the nature of the charge carrier (figure 2).

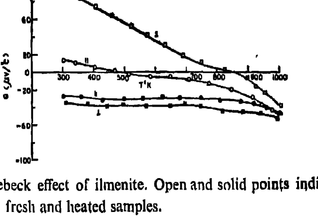

Figure 2 Seebeck effect of ilmenite. Open and solid points indicate measurements on fresh and heated samples.

TABLE 1. ΔE AND σ_0 IN DIFFERENT TEMPERATURE REGIONS

Crystal direction	Fresh (a)			Heated		
	ΔE in ev	σ_0 in $\Omega^{-1}cm^{-1}$	Temperature region °K	ΔE in ev	σ_0 in $\Omega^{-1}cm^{-1}$	Temperature region °K
Basal	.08	5.6	$T<440$	.08	2.3×10^{3}	$T<820$
Plane	.42	5.2×10^{4}	$440<T<590$			
	.18	1.3×10^{2}	$715<T<925$	.50	4.6×10^{4}	$880<T$
	.725	1.8×10^{5}	$925<T$			
C—axis	.10	1.0	$T<400$	.14	1.7×10^{2}	$T<750$
	.20	12.6	$400<T<590$	.50	5.2×10^{4}	$750<T<880$
	.36	1.5×10^{3}	$650<T$	.65	3.2×10^{4}	$910<T$

The studies of the thermo-electric properties show that the nature of the carriers change from *p*-type to *n*-type in fresh samples at high temperatures, and that repeating measurements, the heated samples were found to be entirely *n*-type having higher conductivities. Such changes are most probably due to α-Fe_2O_3 entering into the $FeTiO_3$ lattice (Ishikawa 1958), as also to a lesser degree due to changes in the other impurities present in the samples.

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